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METHOD FOR FORMING SOI FILM
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/1[1]

Specification

1. Title of the invention

Method for Forming SOI Film

2. Claim

A method for forming a SOI film, characterized by the fact that a single crystal silicon embedded into an amorphous insulating film formed on a silicon substrate is used as a seed; and a silicon thin film on the seed and the amorphous insulating film is single-crystallized.

3. Detailed explanation of the invention

(Industrial application field)

The present invention pertains to a method for forming a SOI film.

(Prior art)

As a method for forming a SOI film, a method using a molecular-beam epitaxy is known. In this method, first, a porous silicon is formed on the entire surface of a silicon substrate, and a silicon single crystal is grown by the molecular-beam epitaxy. Then, an area for forming a SOI

[1] Numbers in the margin indicate pagination in the foreign text.

structure is left by processing the silicon epitaxial film, and the porous silicon is oxidized, so that a SOI structure is obtained (Konaka et al., Technical Research Report Vol. 81, SSD 81-25 of the Society of Telecommunication).

Also, as another SOI forming method, a method that recrystallizes a silicon thin film is well known. In this case, it is important to control the crystal orientation of the SOI film, and for controlling the crystal orientation, a method that installs an opening part in part of an insulating film and uses a substrate silicon as a seed for crystal growth is broadly employed. As actual crystal growth methods, furnace heating, solid-phase epitaxy using an energy-beam irradiation, melting crystallization method using an energy-beam irradiation are employed.

(Problems to be solved by the invention)

However, there are the following problems in the conventional SOI formation technique. First, in the method for forming a SOI film by using the molecular-beam epitaxy, since an epitaxial growth is carried out and a SOI structure is obtained by using the oxidation in the horizontal direction of a porous silicon, a SOI region with a wide width cannot be obtained. Furthermore, in the porous silicon oxide, since the etching rate for a hydrofluoric acid system etching solution is higher than

that of the silicon oxide film, the surface step /2 difference is increased during the process. Next, in the method that recrystallizes a silicon film, first, since there is a limitation in the horizontal crystal growth, a large-area SOI cannot be obtained. Also, in the melting crystallization method, since the cooling rate is difference in the seed part in contact with the silicon thin film and the silicon substrate and the SOI part on the insulating film, an optimum SOI formation condition range is narrow.

The purpose of the present invention is to provide a new method for forming a SOI film in which these conventional problems are removed.

(Means to solve the problems)

The method for forming a SOI film of the present invention is characterized by the fact that a single crystal silicon embedded into an amorphous insulating film formed on a silicon substrate is used as a seed; and a silicon thin film on the seed and the amorphous insulating film is single-crystallized.

(Operation)

In the SOI forming method of the present invention, since a silicon single crystal on an insulating film is used as a seed, a SOI structure can be formed on the entire

surface of a wafer. Therefore, even if a porous silicon oxide is used as the insulating film, since the porous silicon oxide does not directly contact with a hydrofluoric acid during the process, the surface step difficult is not large.

Also, since the insulating film usually has a thermal conductivity of only 1/10 of the silicon, a very strong cooling part can be eliminated by using a sample with a structure in which the silicon thin film does not directly contact with the silicon substrate. As a result, the SOI formation condition range of the melting recrystallization method of the silicon thin film can be expanded.

(Application example)

Next, an application example of the present invention is explained in detail referring to the figures. Figure 1 is a cross section showing a sample structure of an application example of the present invention. 1 is a silicon substrate, and a porous silicon oxide film 2 was formed on its surface by a process that will be mentioned later, so that a single crystal silicon 3 was separated. Then, an amorphous silicon film 4 was deposited on the entire surface, so that the structure of Figure 1 was obtained. Figures 2(a)-(d) show the processes for separating the single crystal silicon from the silicon

substrate. In Figure 2(a), 5 is a silicon nitride film, and 6 is a resist. In this application example, the pattern of the silicon nitride film was a stripe shape with a width of 5 μm, and the stripe interval was 20 μm. Next, a boron ion implantation 7 was carried out, and a p^+ layer 8 was formed. Then, a proton ion implantation 9 was carried out, and annealing was applied at 400°C, so that a n type layer was formed under the nitride film pattern (Figure 2b). Then, a porous silicon 11 was formed by an anodization in hydrofluoric acid (Figure 2(c)). Then, the porous silicon was thermally oxidized, and a structure in which the silicon single crystal was embedded onto the porous silicon oxide film was obtained (Figure 2(d)).

The single crystallization of the amorphous silicon film 4 of Figure 1 was carried out by a solid-phase epitaxy using an electric furnace heating at 650°C. As a result, a SOI structure could be formed on the entire surface of a 4-inch wafer.

The amorphous silicon film can also be recrystallized by the melting recrystallization using a beam annealing. In this case, it is important that the single crystal silicon being a seed is not completely melted and the seed effect remains. It is necessary to obtain a thick single crystal silicon by implanting protons ions as deeply as

possible and to raise the insulation effect, compared with the seed part, by thickening the cap film of the SOI part other than the seed part. Also, a polysilicon film may be used instead of the amorphous silicon film in the melting recrystallization method.

(Effects of the invention)

According to the present invention, a large-area SOI film can be formed on the entire surface of a wafer, so that a high densification of a SOI device is made possible. Also, in case a SOI film is formed by a beam irradiation, optimum SOI formation conditions can be employed, so that a high-quality SOI film can be formed.

4. Brief description of the figures

Figure 1 is a cross section showing a sample structure of the present invention, and Figure 2 is a cross section showing the processes for separating a silicon single crystal from a silicon substrate by a porous silicon. In the figures, 1 is a silicon substrate, 2 is a porous silicon oxide film, 3 is a single crystal silicon, 4 is an amorphous silicon film, 5 is a silicon nitride film, 6 is a resist, 7 is a boron ion implantation, 8 is a p^+ layer, 9 is a proton ion implantation, 10 is a n type layer, and 11 is a porous silicon.

第1図

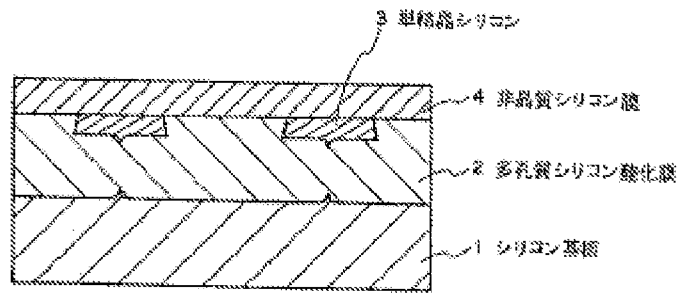

Figure 1:

1 Silicon substrate

2 Porous silicon oxide film

3 Single crystal silicon

4 Amorphous silicon film

第 2 図

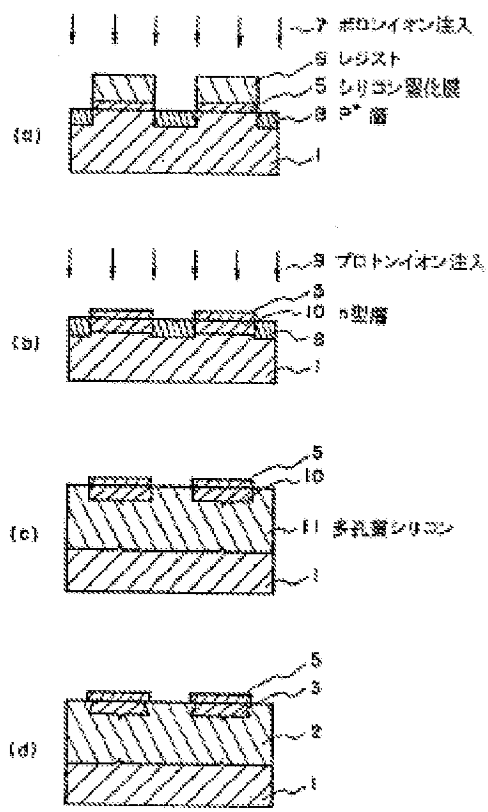

Figure 2:

5 Silicon nitride film

6 Resist

7 Boron ion implantation

8 p^+ layer

9 Proton ion implantation

10 n type layer

11 Porous silicon